19TH ANNUAL INTERNATIONAL RADIANCE WORKSHOP

Organized by

Universidad del País Vasco / Euskal Herriko Unibertsitatea

SCHOOL OF ARCHITECTURE
UNIVERSITY OF THE BASQUE COUNTRY

Architecture Department, University of the Basque Country
www.ehu.eus

LOISOS + UBBELOHDE
ARCHITECTURE . ENERGY . LIGHT

Loisos + Ubbelohde, California, USA
www.coolshadow.com

Simulation of daylight by Radiance in dense urban areas

Urtza Uriarte Otazua

Quality of Life in Architecture (caviar)– Architecture Department, UPV/EHU (San Sebastián)
urtza.uriarte@ehu.eus
urtza.uriarte@gmail.com

Physique Urbaine, ISA-BTP-UPPA Anglet

CONTEXT: DENSE URBAN AREAS

Many **cities** have **dense urban areas** such as the old town.

Old Town of Donostia – San Sebastián.

ISSUE

Darks,

wet,

unhealthy

CURRENT STATE

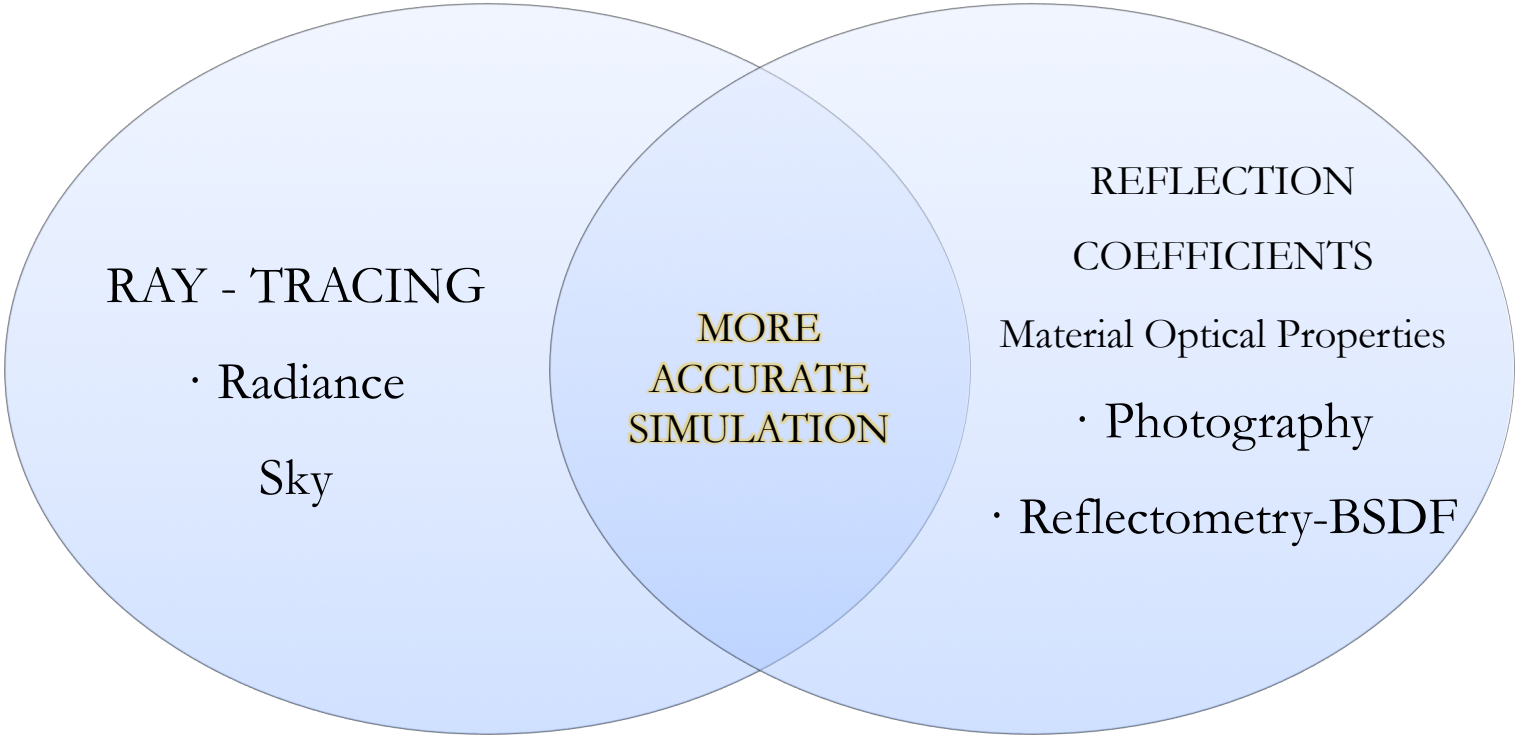
Need for enhancement.

Have its dimension.

Paint everything white.

OBJECTIVE

Simulating rooms with low-light: and this requires **precision**.


RAY - TRACING
· Radiance
Sky
MORE ACCURATE SIMULATION
REFLECTION COEFFICIENTS
Material Optical Properties
· Photography
· Reflectometry-BSDF

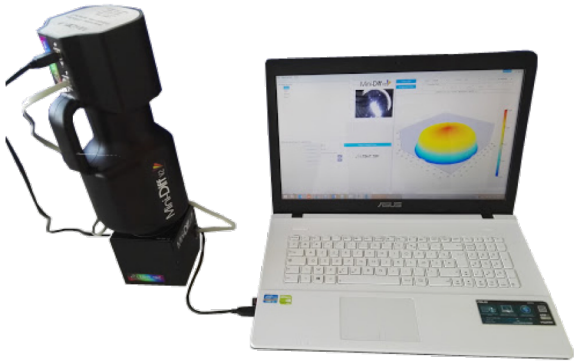
INTERIOR
Esterlines Street 3-1º

Old Town of Donostia-
San Sebastián

LIGHT WELL
Esterlines – Narrika – Enbeltran

MEASUREMENT CAMPAIGN: FIRST ONE: DATA

- Date: 26/05/21
- Site: Light Well Esterlines Street 3-1º, Old Town of San Sebastián
- Measurement Frequency: Every hour (16.00-20.00)
- Measurement site: **Roof** and the **first floor interior** room with window to light well
- **2 luxmeters**: 1 at the roof; and 1 at first floor interior (25 cm from the window and 40 cm from the wall)
- **1 camera**: Sky and interior photographs, hourly
- **1 reflectometer**: Optical properties with interior walls BSDF
- Sky Type: Intermediate, starting with half-overcast and turning to clear sky



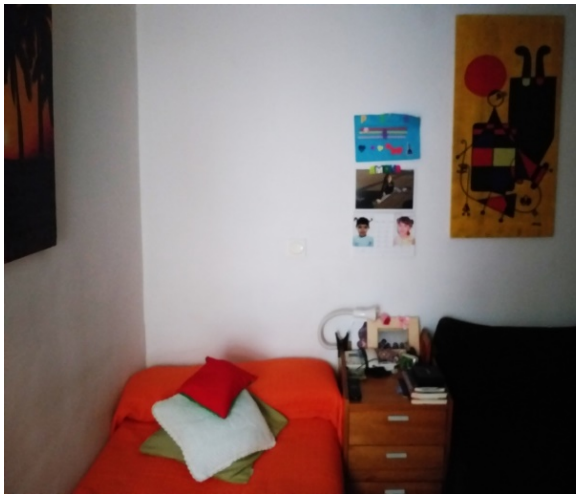
MEASUREMENT CAMPAIGN: MEASUREMENT POINTS

Roof-Sky

Photography

Light level

Window to light well



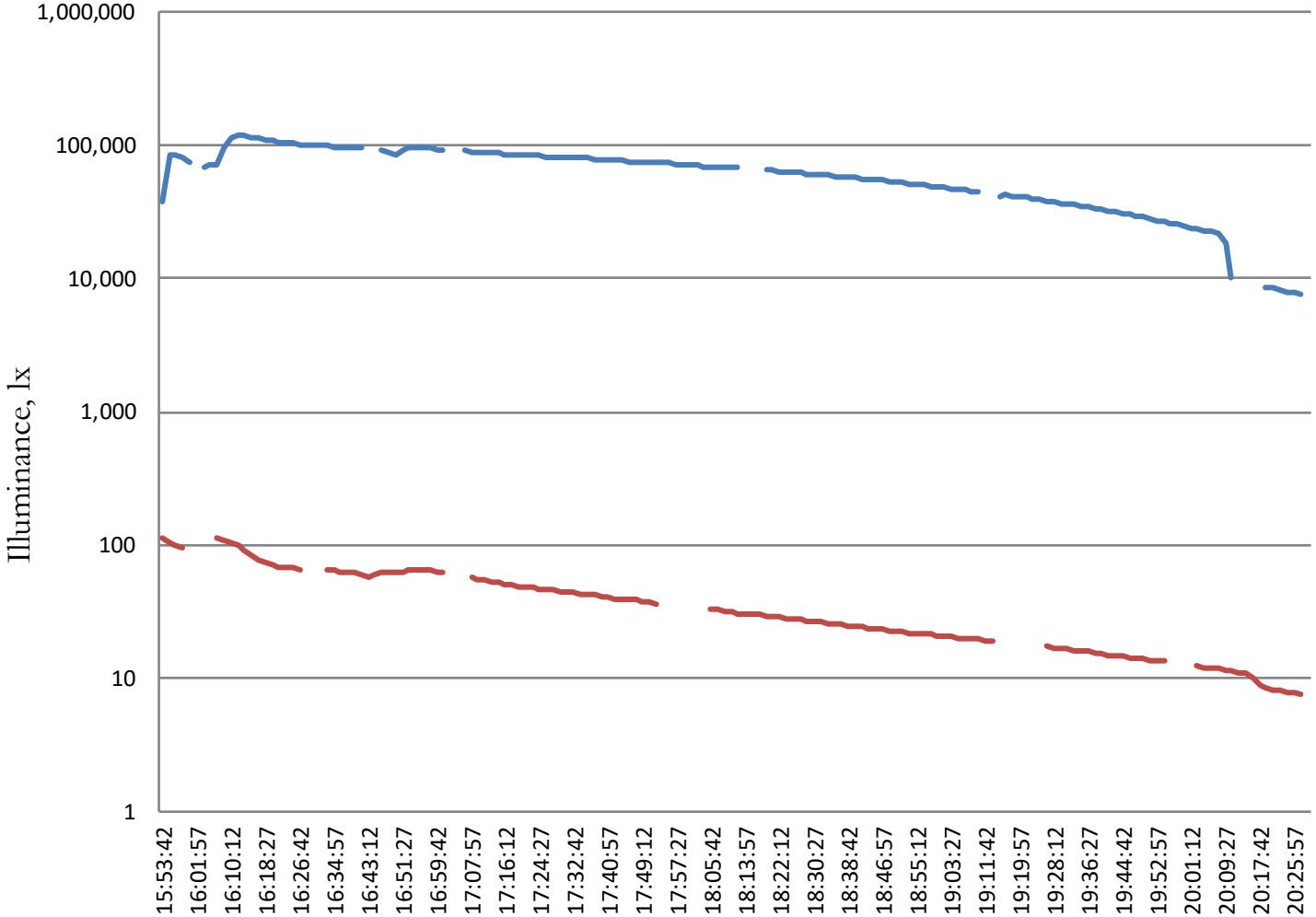
Interior – Surfaces

Light level

Photography

BSDF

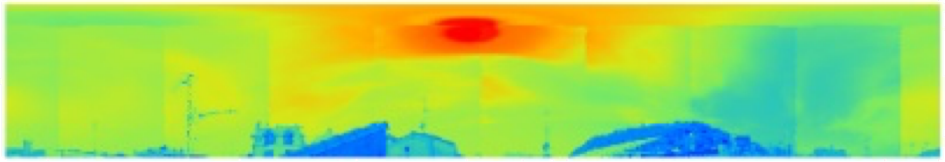
MEASUREMENT CAMPAIGN: RESULTS: LIGHT LEVEL

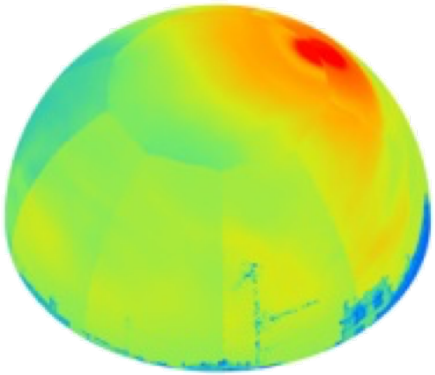


Lambert Projection

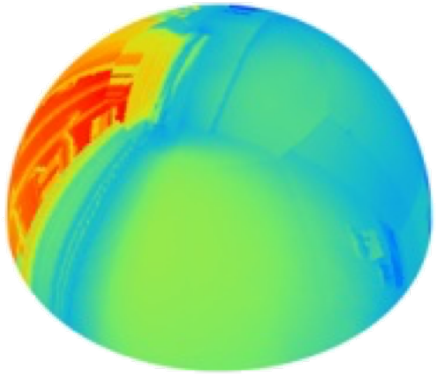
Hemisphere projection

SKY

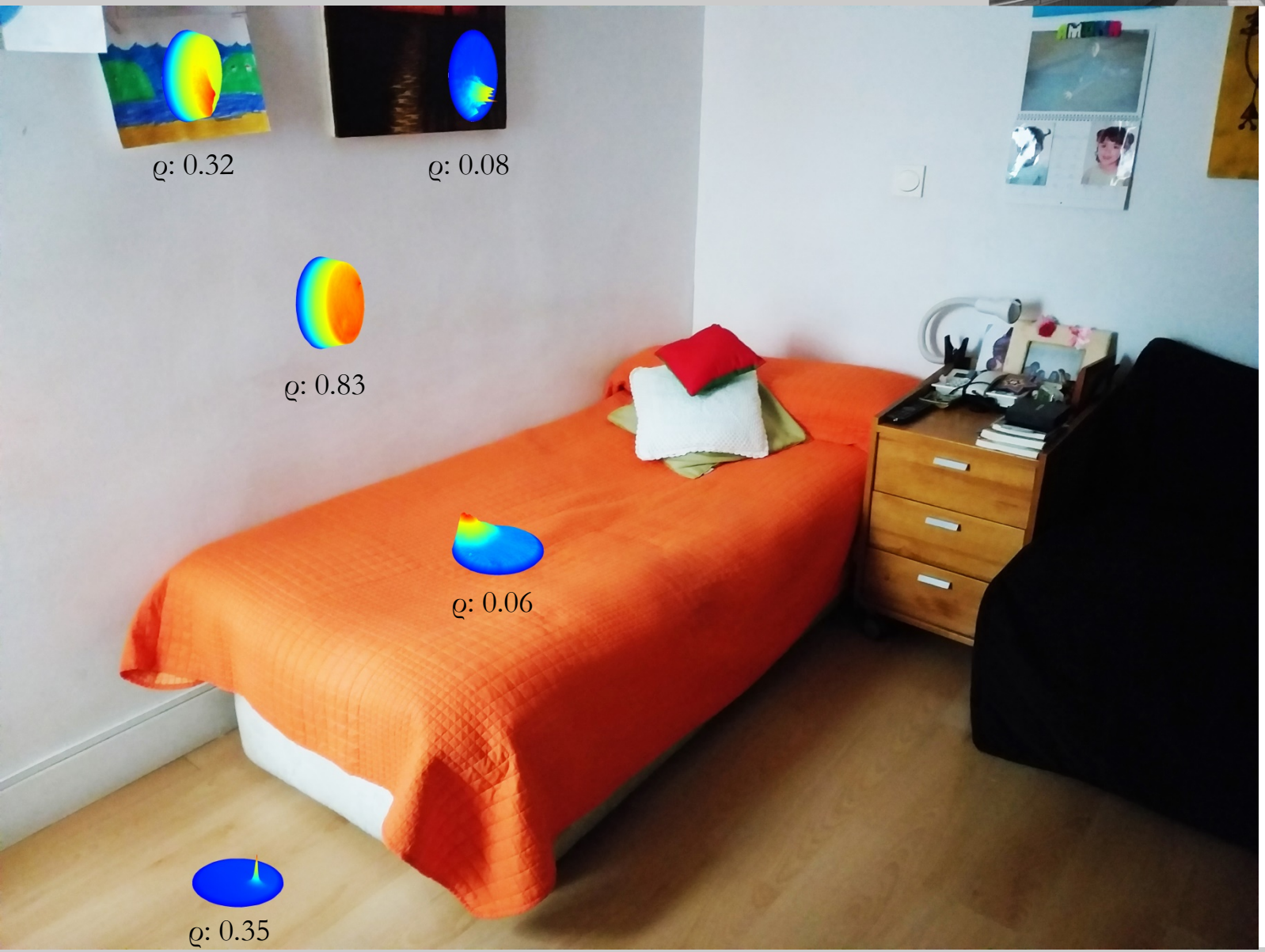




INTERIOR_1st F



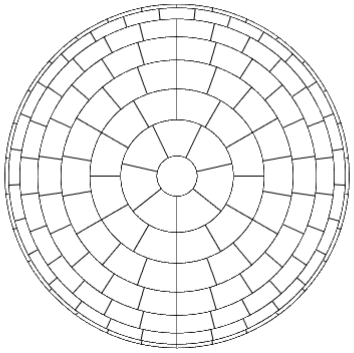
MEASUREMENT CAMPAIGN: OPTICAL PROPERTIES



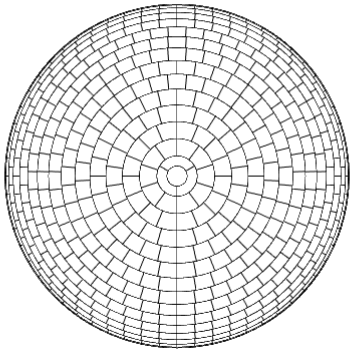
Reflection coefficients

Reflectometer BSDF

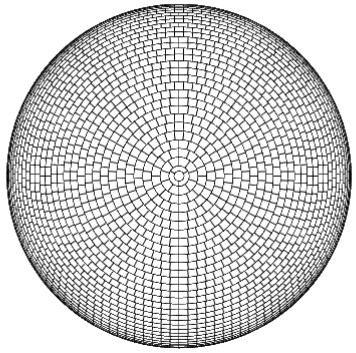
SKY DIFFERENT DISCRETIZATIONS



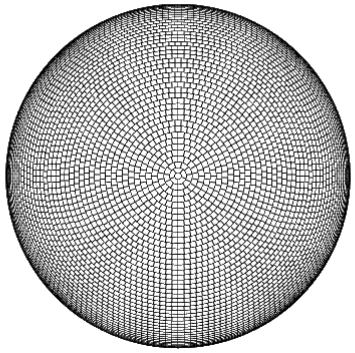
145 divisions
Tregenza



580 divisions
Reinhart MF:2



2305 divisions
Reinhart MF:4

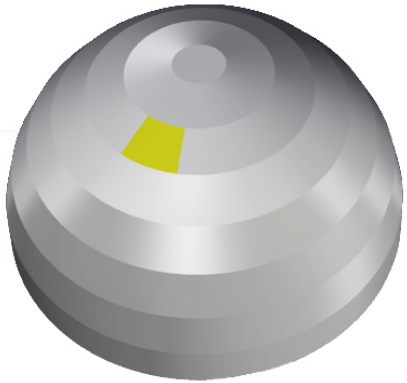


5000 divisions
Benoit Beckers[1]

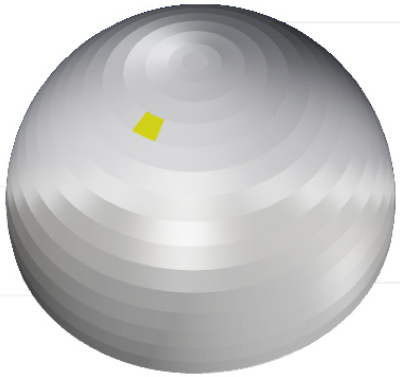
[1] B. Beckers, P. Beckers, A general rule for disk and hemisphere partition into equal-area cells, Comput. Geom. 45 (2012) 275–283

SKY DIFFERENT DISCRETIZATIONS

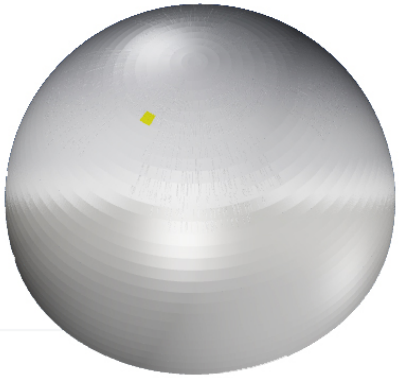
gensky
genskyvec



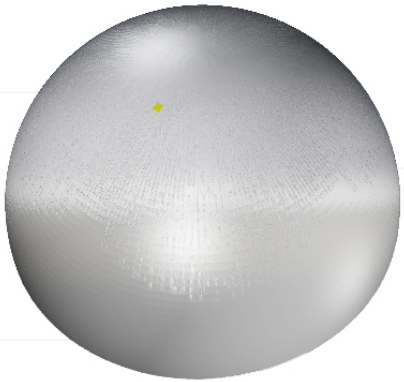
145 divisions



580 divisions

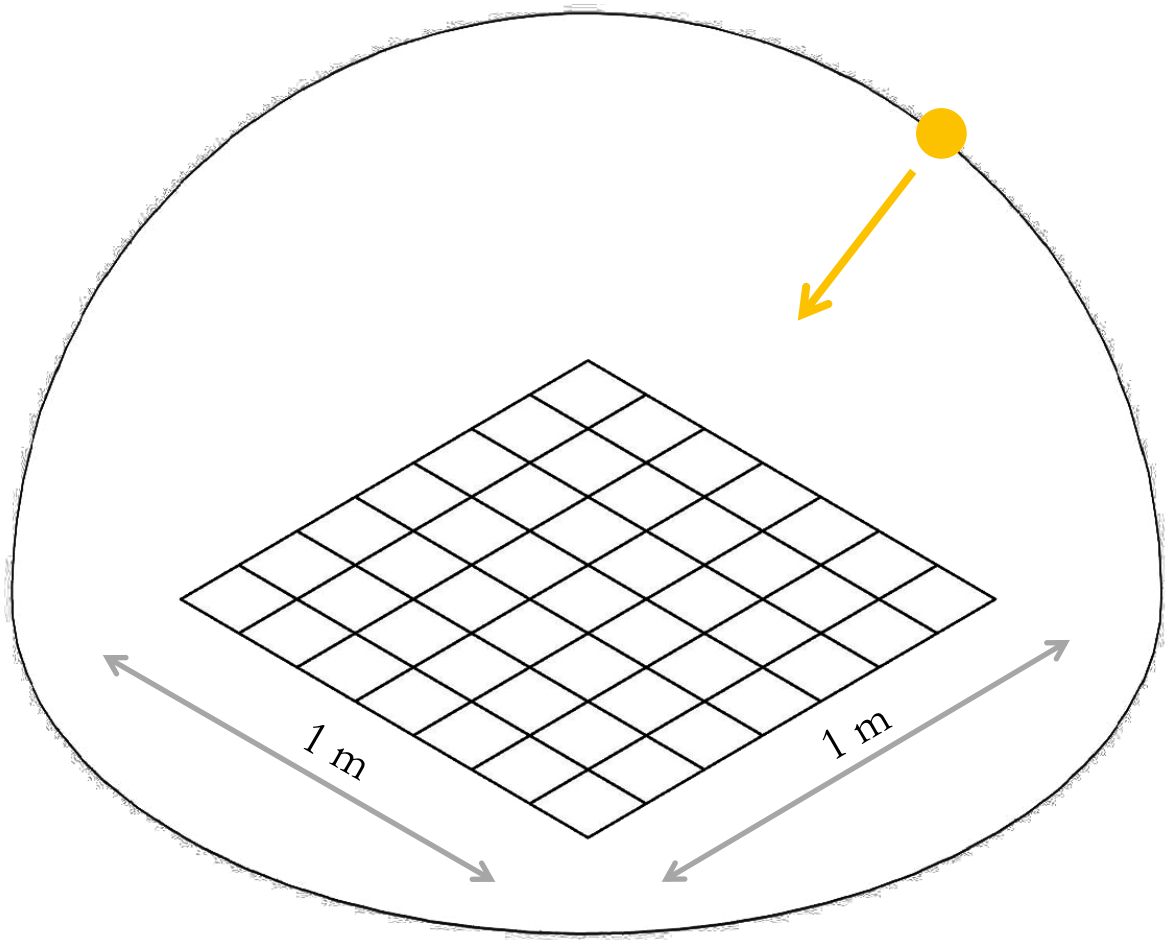


2305 divisions



5000 divisions

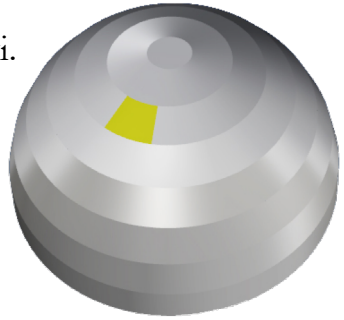
SKY EXTERIOR WORK PLANE



Hypothesis:

If the **sky partition** is **not accurate** the probability of **direct radiation** will be **overestimated**.

145 divi.



gensky 03 21 12 +s -a 41 -o -2 -m -15
| genskyvec -m 1

2-Phase Method

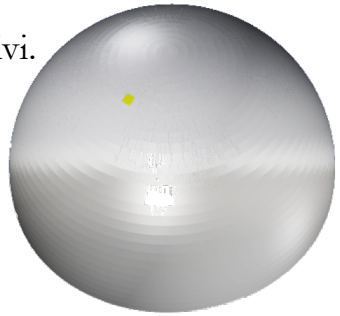
Parameters command ***rfluxmtx***

-ab 6 -ad 1000000 -lr 10

Illuminance, lx

Max: 60 098 lx
Min: 60 019 lx

2305 divi.



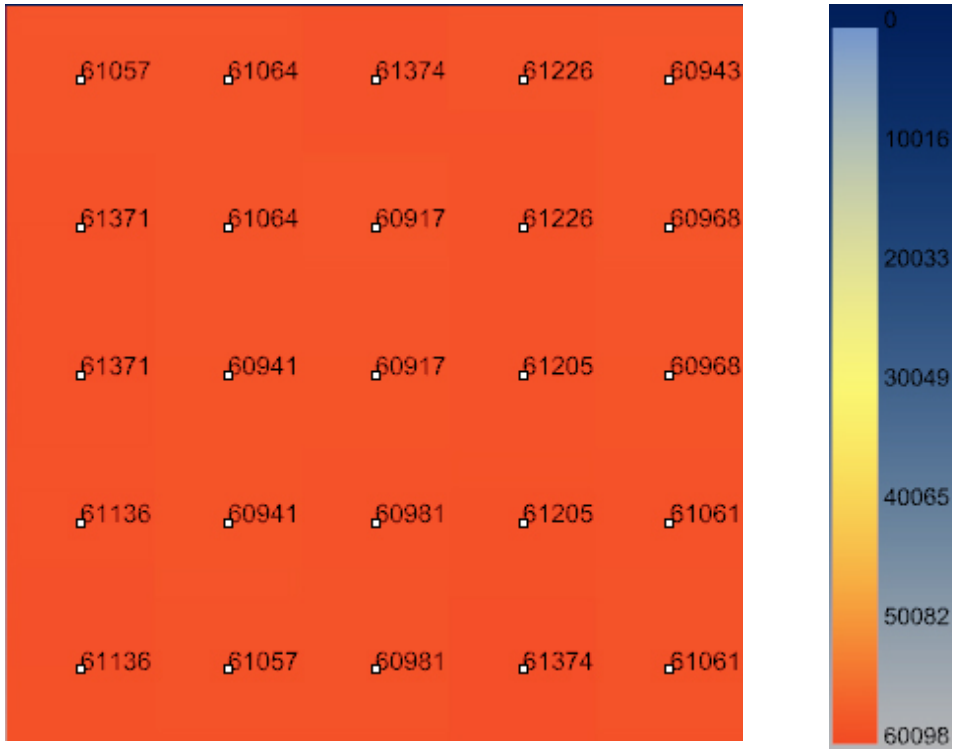
gensky 03 21 12 +s -a 41 -o -2 -m -15
| genskyvec -m 4

2-Phase Method

Parameters command ***rfluxmtx***

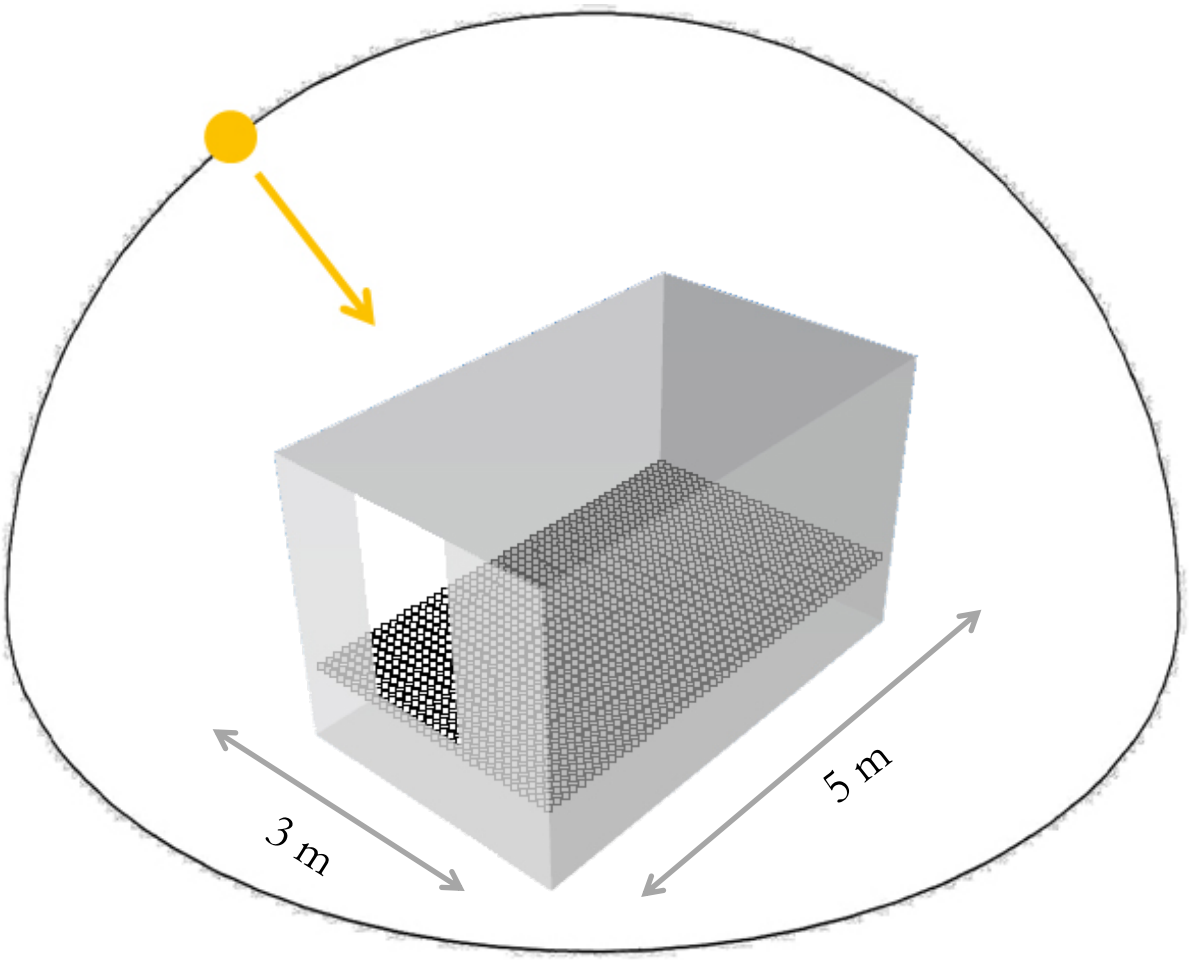
-ab 6 -ad 1000000 -lr 10

Illuminance, lx



Max: 61 374 lx
Min: 60 917 lx

SKY INTERIOR WORK PLANE

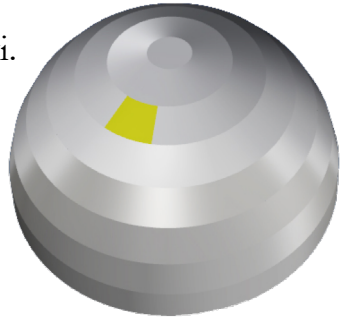


Interior

1581 sensor points.

Test with different sky partition.

145 divi.



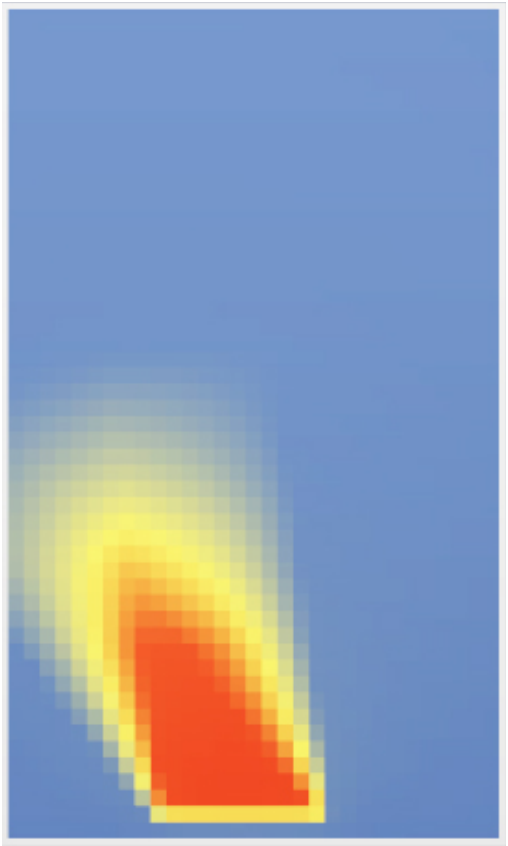
gensky 03 21 12 +s -a 41 -o -2 -m -15
| genskyvec -m 1

2-Phase Method

Parameters command ***rfluxmtx***

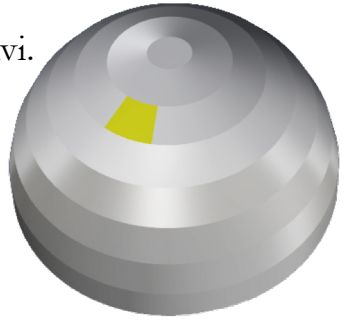
-ab 6 -ad 10000 -lr 10

Max: 55 184 lx
Min: 0 lx



Illuminance, lx

2305 divi.



gensky 03 21 12 +s -a 41 -o -2 -m -15
| genskyvec -m 1

2-Phase Method

Parameters command ***rfluxmtx***

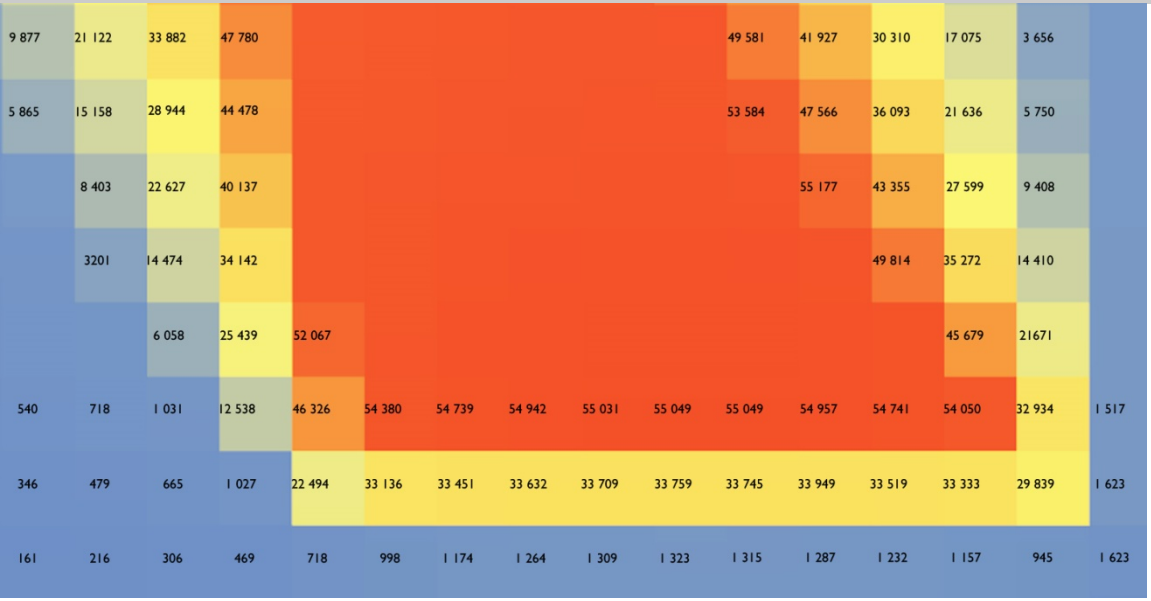
-ab 6 -ad 10000 -lr 10

Illuminance, lx

Max: 56 510 lx
Min: 0 lx

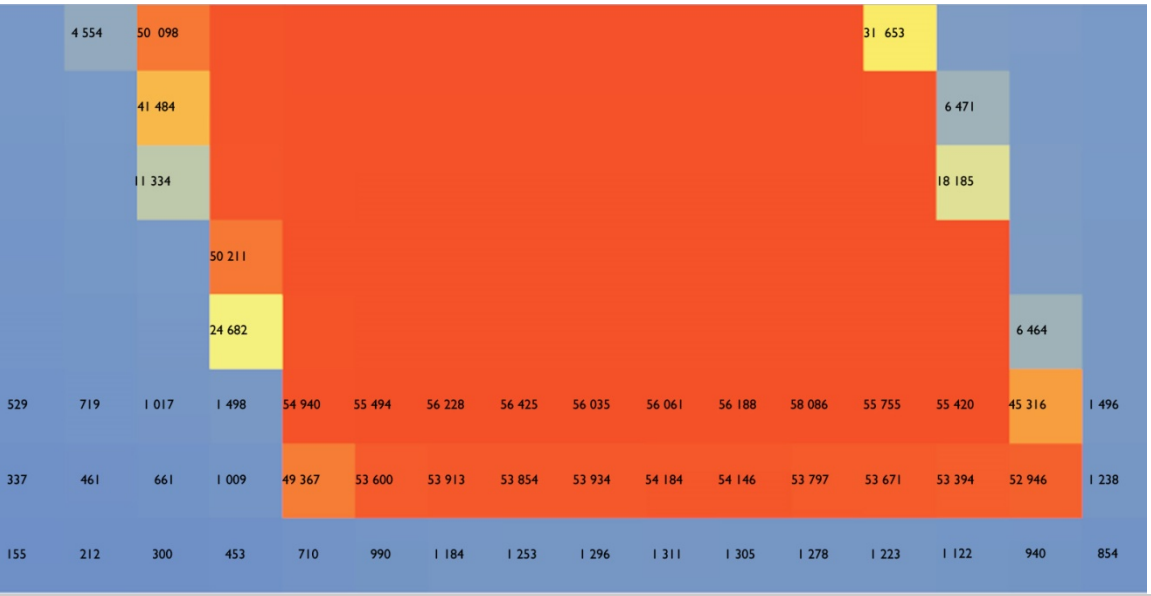
SIMULATION

RESULTS: COMPARISON



145 divisions

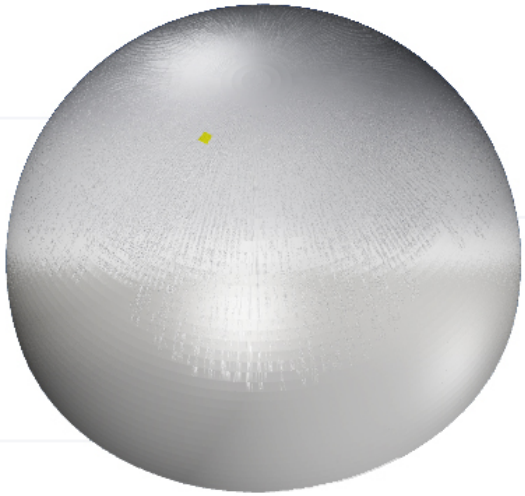
Illuminance, lx

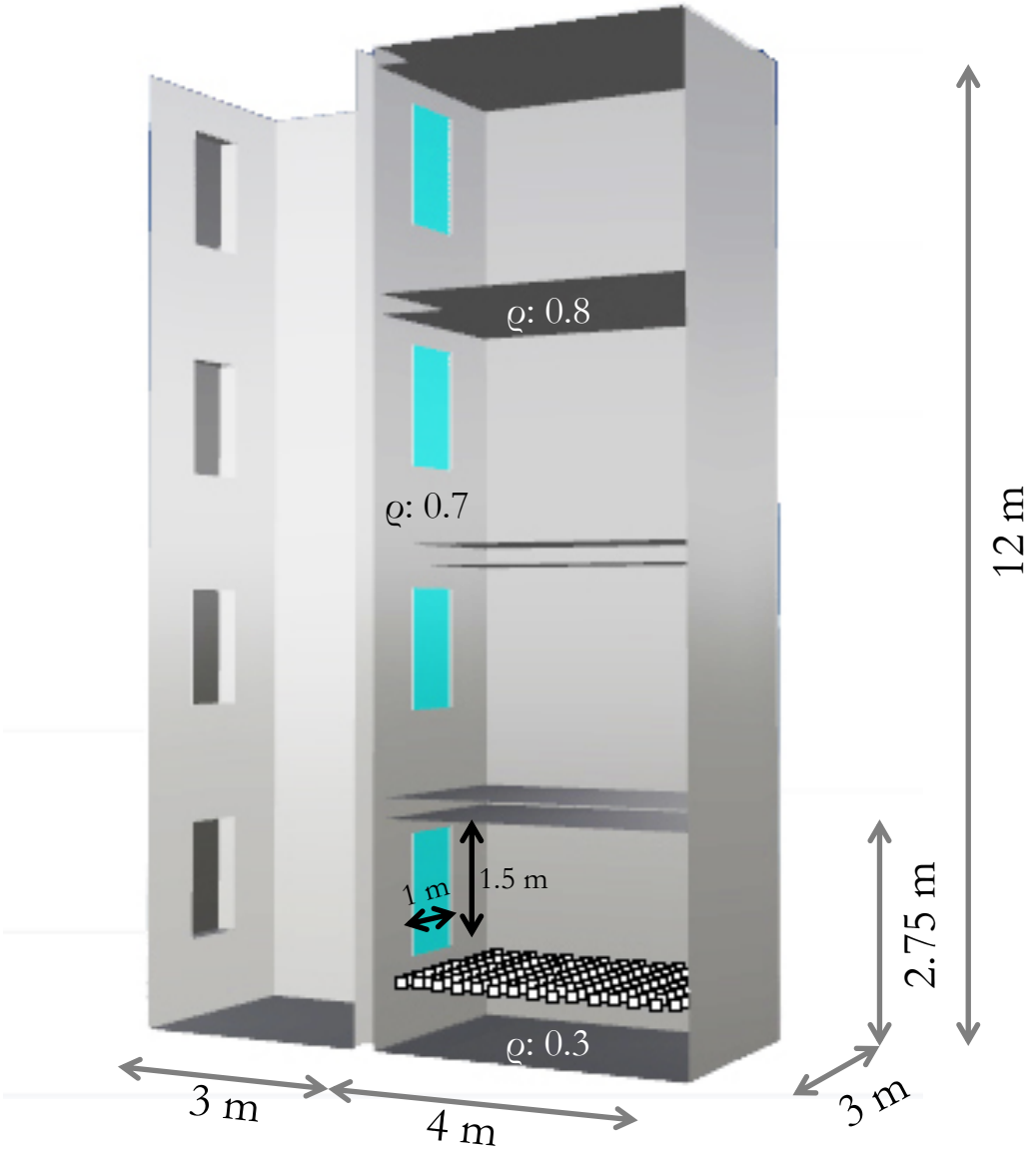


2305 divisions

In this context of low-light, it would be useful to get more sky divisions, such us 2305 divisions, or more to probe whether the results will be more accurate.

5000 divisions.





4 floors

Sensor Grid:

- 4 x 3 m;
- 0.25 m between sensors

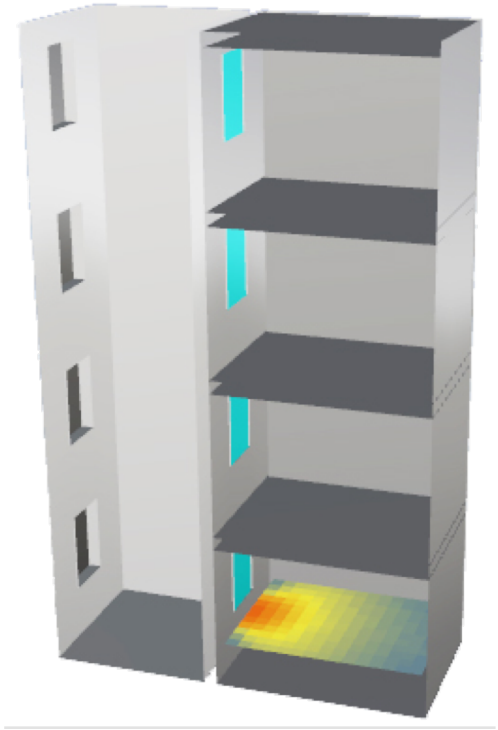
Walls width: 0.25 m

Window Glazing:

- single pane;
- specular reflection 0.08;
- direct transmittance 0.88

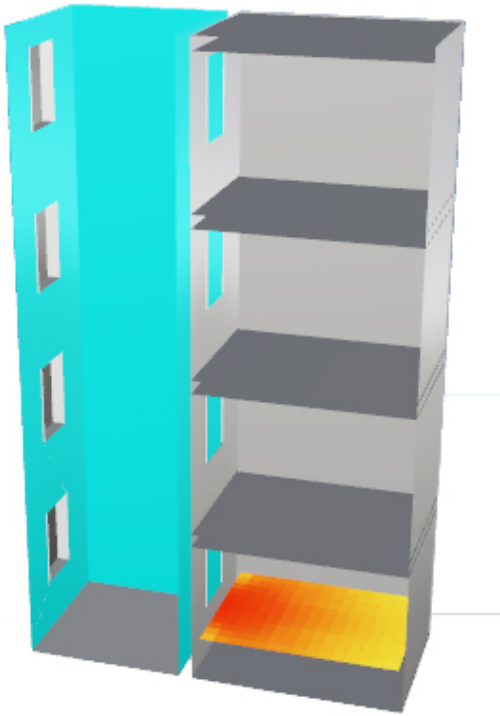
Threshold: 100 lx

Diffuse Surface 0.85



-ab 30 -ad 1000000 -lr 30 2305 divisions
2.78 h/day
2h47 Radiosity: 2h53

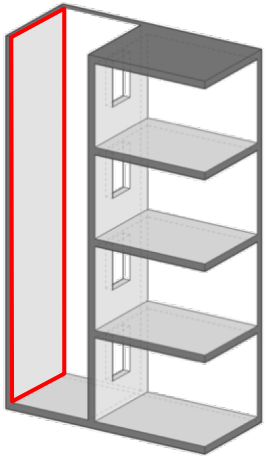
Specular Surface



-ab 30 -ad 1000000 -lr 30 2305 divisions
9.11 h/day
9h07 Radiosity: 9h12

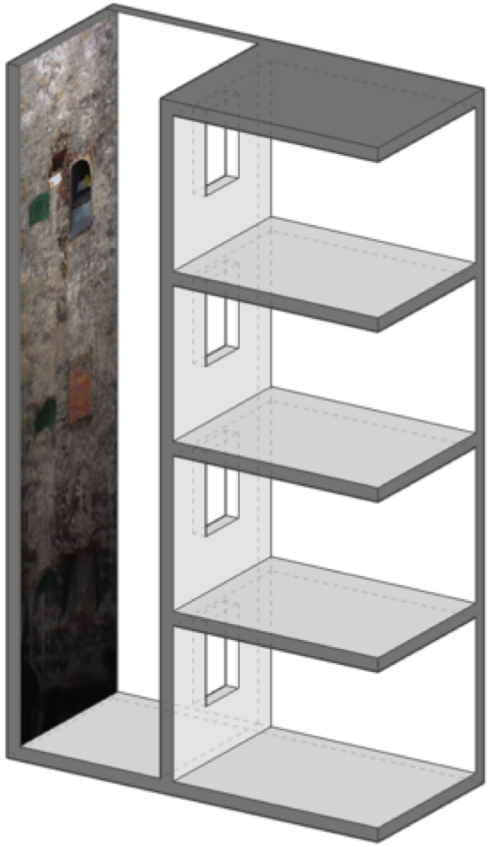
SIMULATION PROCESS STANDARD LIGHT WELL: REFLECTION COEFFICIENTS

More accurate reflection coefficients for a real WALL of a Light Well

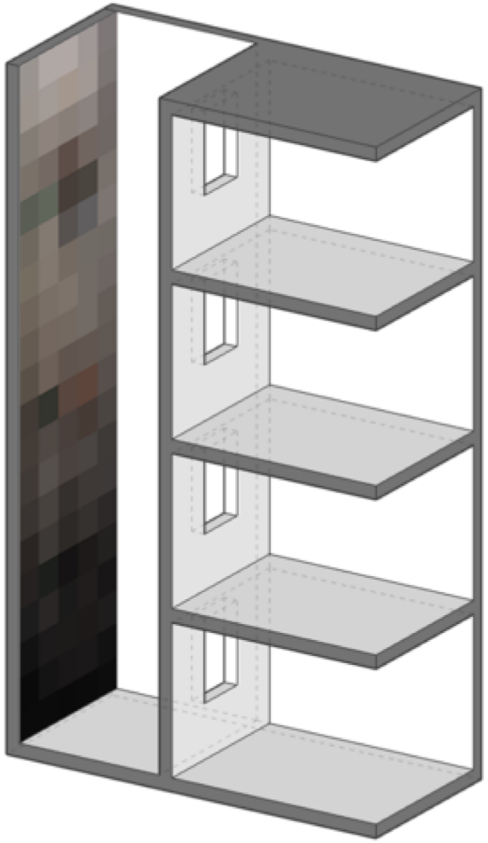


Light Well that we are measuring; coefficients reflections from photographed front wall

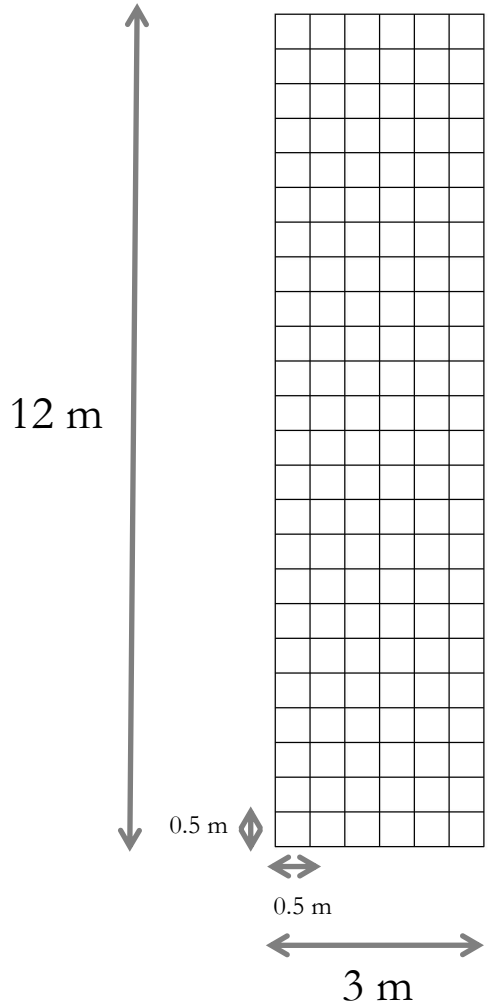
Photography



Quartering

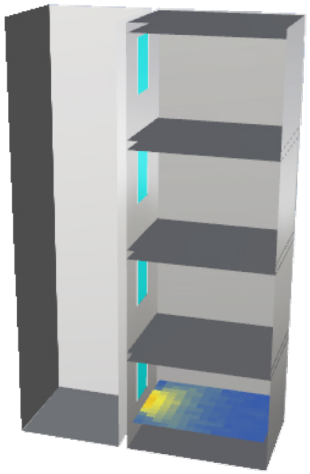


The reflection coefficient of each quartering of the wall



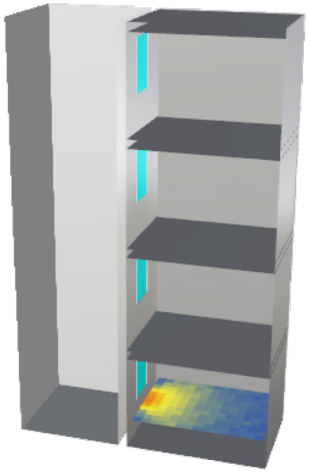
0,765	0,792	0,733	0,710	0,737	0,718
0,757	0,753	0,737	0,753	0,757	0,753
0,788	0,773	0,710	0,565	0,671	0,796
0,745	0,761	0,737	0,557	0,627	0,737
0,745	0,753	0,741	0,722	0,678	0,667
0,714	0,741	0,710	0,718	0,757	0,714
0,690	0,714	0,737	0,737	0,718	0,714
0,757	0,757	0,749	0,749	0,725	0,757
0,698	0,729	0,686	0,686	0,773	0,765
0,620	0,729	0,737	0,706	0,678	0,725
0,745	0,796	0,741	0,690	0,753	0,749
0,694	0,749	0,675	0,631	0,694	0,671
0,667	0,694	0,667	0,627	0,635	0,729
0,718	0,655	0,651	0,620	0,718	0,647
0,776	0,733	0,647	0,667	0,784	0,659
0,773	0,757	0,718	0,631	0,773	0,722
0,698	0,702	0,749	0,737	0,706	0,565
0,718	0,710	0,565	0,671	0,749	0,702
0,745	0,698	0,671	0,655	0,761	0,616
0,647	0,620	0,694	0,667	0,639	0,518
0,580	0,608	0,541	0,482	0,643	0,518
0,553	0,561	0,431	0,537	0,706	0,537
0,494	0,624	0,549	0,447	0,600	0,529
0,533	0,576	0,502	0,388	0,525	0,557

DA, 1 coeficiente de 0.3



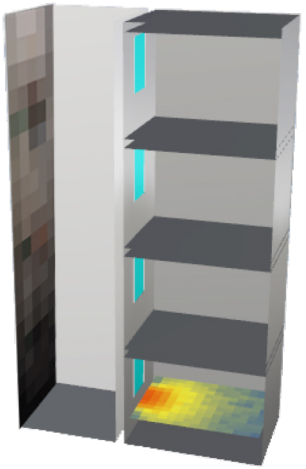
-ab 30 -ad 10000 -lr 30
145 divisions
1h14

DA, 1 coeficiente de 0.5



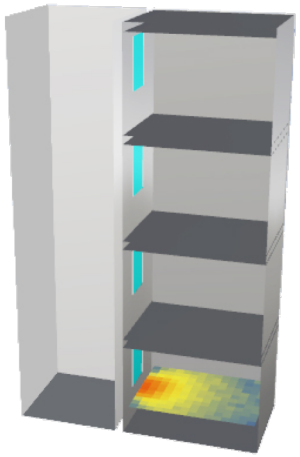
-ab 30 -ad 10000 -lr 30
145 divisions
2h13

DA, 24F x 6C coef.



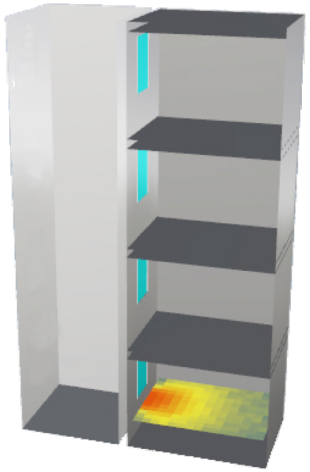
-ab 30 -ad 10000 -lr 30
145 divisions
3h56

DA, promedio 1 coef. 0.75



-ab 30 -ad 10000 -lr 30
145 divisions
3h58

DA, 1 coeficiente de 0.85

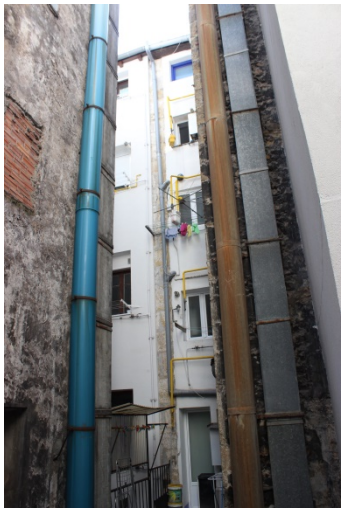


-ab 30 -ad 10000 -lr 30
145 divisions
4h49

Defining the minimum detail of the simulation is relevant for more accurate results under low daylight level, at least:

- ✓ Sky division: 2305
- ✓ Reflection coefficients: measured BSDF of determinant surfaces
- ✓ ***rfluxmtx*** parameters: -ab 30 -ad 1000000 -lr 30
- ✓ Modelled surfaces: 0.25 m x 0.25 m

- ✓ Modelling the real Light Well, for which we have already made the first measurements.



- ✓ Get the calibrated simulations according with mentioned specifications
- ✓ Coloured luminous surfaces can create a more comfortable atmosphere.

- ✓ Improving daylight **conduction** by simulating different **finishes** of surfaces or with **skylight Complex Fenestration System**

DEPLOSUN

THANK YOU

GRACIAS

ESKERRIK ASKO